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PATENT

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TITLE: VARIABLE DIE FOR USE IN DRYING SYNTHETIC ELASTOMERS

PRIORITY CLAIM

Applicant claims priority to an application filed in the United States Patent and Trademark Office on May 30, 2003, entitled "Adjustable Extruder Die", with Application Serial No. 60-474445 and Reference No. P50-0108.

FIELD OF THE INVENTION

[0001] The present subject matter relates to synthetic elastomers and, more particularly, to methodologies and apparatus for drying, i.e., removing moisture, from such elastomers.

BACKGROUND OF THE INVENTION

[0002] Expeller-expander technology is a processing technique that has been available in various forms dating back to the nineteenth century. The present area of concern relates to that area of an elastomer processing sequence (including synthetic and natural elastomers) where the rubber material has been combined with water and now the water is to be removed.

[0003] In previously used configurations, two extruders in series have been employed to remove moisture from the rubber. Generally, the first extruder, also referred to as the expeller, squeezes the rubber between a pair of intermeshed screws. This portion of the process is generally able to reduce the moisture content from about 60% to about 15%.

[0004] Following the first stage of the drying process by the expeller, the rubber material is passed to a second extruder referred to as an expander for additional drying. This second extruder increases pressure on and consequently the temperature of the rubber, thus creating a super heated liquid. As this super heated liquid is forced through the extruder,

again commonly by using screw drive technology, the material is forced through dies or filter screens at the end of the screw where the moisture, or volatile matter, will flash dry.

[0005] The flash drying process corresponds to a rapid change in state from liquid to vapor as the supper heated rubber material passes through the die or filter screen and suddenly returns to normal atmospheric pressure while the water temperature may still be significantly higher than 100 degrees Celsius. The energy necessary to produce the flash drying phenomena is transferred to the rubber from the screw drive mechanism in the expander. This transfer of energy is made possible by the resistance of the rubber to exit the expander through the dies. The temperature and pressure on the super heated rubber reach a maximum at the dies, thus for a given screw speed and rubber flow rate, the resistance, and therefore the amount of energy transferred to the rubber, is dependent on the pressure at the head.

[0006] The pressure is fixed by the pressure drop induced by the passage of the super heated rubber through the die. In a practical system, there will be a number of dies at the exit point of the expander and thus the pressure will depend on the number of dies, their geometry and aperture size. In previously employed configurations, all of these aspects of the dies were fixed with any one processing sequence. Because the prior art is a fixed and unchangeable configuration, certain production problems have occurred that the present technology addresses and overcomes.

[0007] When the super heated rubber goes through the dies, the flash drying process produces decohesion of the rubber thereby creating rubber crumbs that are transported to balers for further processing. The control of the size of these crumbs is one of the aspects effecting good transportation of the rubber through the remaining processing sequences and, consequently, can have an impact on further processing. For example, reduction of conveyor fouling can occur based on production of too small a crumb size. As the currently available technology employs preset die configurations, no capability other than stopping production is available to address issues involving pressure adjustment and crumb size. Moreover, there is no capability for optimizing the overall rubber processing process outside of controlling the expeller-expander screw speed without shutting down production.

[0008] While various implementations of extruder-expander technology have been developed, no design has emerged that generally encompasses all of the desired characteristics as hereafter presented in accordance with the subject technology.

SUMMARY OF THE INVENTION

[0009] In view of the recognized features encountered in the prior art and addressed by the present subject matter, an improved methodology for drying synthetic elastomeric materials has been developed. The present technology, therefore, is directed to methodologies and apparatus that provide for the optimization of the pressure at the die or filter screen without the necessity of shutting down production.

[0010] In an exemplary embodiment of the present subject matter, apparatus and accompanying methodologies are provided for dynamically optimizing the overall operation of an extruder-expander system that does not require shutting down production to achieve optimized operation of the system.

[0011] In a further exemplary embodiment of the present subject matter, methodologies and apparatus are provide that allows crumb size adjustment during the production process without having to resort to expander shut down to alter the die set up.

[0012] In yet a further exemplary embodiment of the present subject matter, pressure at the die head as well as crumb size may be automatically controlled.

[0013] Additional objects and advantages of the present subject matter are set forth in, or will be apparent to, those of ordinary skill in the art from the detailed description herein. Also, it should be further appreciated that modifications and variations to the specifically illustrated, referred and discussed features and elements hereof may be practiced in various embodiments and uses of the invention without departing from the spirit and scope of the subject matter. Variations may include, but are not limited to, substitution of equivalent means, features, or steps for those illustrated, referenced, or discussed, and the functional, operational, or positional reversal of various parts, features, steps, or the like.

[0014] Still further, it is to be understood that different embodiments, as well as different presently preferred embodiments, of the present subject matter may include various combinations or configurations of presently disclosed features, steps, or elements, or their equivalents (including combinations of features, parts, or steps or configurations thereof not expressly shown in the figures or stated in the detailed description of such figures). Additional embodiments of the present subject matter, not necessarily expressed in the summarized section, may include and incorporate various combinations of aspects of

features, components, or steps referenced in the summarized objects above, and/or other features, components, or steps as otherwise discussed in this application. Those of ordinary skill in the art will better appreciate the features and aspects of such embodiments, and others, upon review of the remainder of the specification.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] A full and enabling disclosure of the present invention, including the best mode thereof, directed to one of ordinary skill in the art, is set forth in the specification, which makes reference to the appended figures, in which:

[0016] Figure 1 illustrates an expander head and shows a die head set up employing four separated die heads;

[0017] Figure 2 illustrates a cross sectional view taken along line 2-2 of Figure 1 and showing a die head in accordance with the present subject matter;

[0018] Figure 3 illustrates a second cross sectional view of the die head illustrated in Figure 2 and shows the adjustability aspect of the present subject matter;

[0019] Figure 4 illustrates a cross sectional view of a die head in accordance with the present subject matter in an operational state; and

[0020] Figure 5 illustrates and exploded view of a die head in accordance with the present subject matter.

[0021] Repeat use of reference characters throughout the present specification and appended drawings is intended to represent same or analogous features or elements of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0022] With reference now to Figure 1, there is illustrated an expander head 100 configured to house four separate die heads 110. It should be appreciated that, although four die heads 110 are illustrated in the present configuration, such is exemplary only as the number of die heads may vary depending on processing requirements such as the specific type of synthetic elastomer being processed. Shown also is a relief valve port 120 and operating handle 122 that may be used to make sure the pressure in the expander has been relieved at those times when it becomes necessary to shut down the production line and/or service the expander head 100. Control shaft 130 may be coupled to a control mechanism and is employed to dynamically adjust the die settings as will be more fully explained later. It should be appreciated that control shaft 130 and its accompanying control mechanism may be associated with automated control equipment, not illustrated, for automatically controlling

the opening size of the variable die of the present subject matter in accordance with specific processing requirements as will be more fully explained later.

[0023] Figures 2 and 3 are both cross sectional illustrations taken along line 2-2 illustrated in Figure 1 of the variable die in accordance with the present exemplary embodiment. Figures 2 and 3 illustrate, respectively, a relatively "closed" position and a relatively "open" position of the variable die. As seen from both Figures 2 and 3, the variable die of the present subject matter is constructed from three major portions: a die body 200, an adjustment sleeve 220, and a filter screen 240. Die body 200 may be secured to the extruder head 100 by means of threaded portion 202 cooperating with a matching threaded coupling means, not shown, on the extruder head. An aspect of die body 200 of particular significance to the present subject matter resides in the provision of a beveled or conical surface 204 that, together with conical surface 244 of filter screen 240 forms a pressure adjusting system as will be more fully explained later. With further reference to Figures 2 and 3, it will be noted that die body 200 is fitted with an additional threaded portion 206, the threads of which are configured to mate with threaded portion 226 of adjustment sleeve 220.

[0024] Adjustment sleeve 220, as shown, is configured to overlie and threadedly engage die body 200 in a pressure sealed manner. Improved sealing capability is supplied through the use of O-ring seal 208 positioned between an outer lateral end portion 210 of die body 200 and an inner surface 230 of adjustment sleeve 220. Adjustment sleeve 220 is expanded at one end portion 232 thereof and internally threaded with threads 234 that cooperate with matching threads 246 on the outer periphery of filter screen 240.

[0025] Filter screen 240, as mentioned, has outer periphery threads 246 that cooperate with threads 234 of the adjustment sleeve 220 in such manner as to hold filter screen 240 securely in place by tightly seating the threaded filter screen 240 into the threaded expanded portion 232 of the adjustment sleeve 220. Filter screen 240 is perforated with a plurality of uniformly spaced flash channels 250, as best seen in Figures 1 and 5. As with the previously noted exemplary illustration of four die heads 110 illustrated in Figure 1 as mounted in the extruder head 100, the exact number of flash channels 250 provided in each die head 110 will vary depending on specific requirement relating to the particular type of material being processed.

[0026] Acting as, *inter alia*, a distributor to the plurality of flash channels 250 of the material being processed is another significant feature of the present subject matter seen in

the form of turbulence channel 268. By design, turbulence channel 268 is configured within the filter screen 240 in such manner as to provide at least a minimum volume regardless of the relative position of the adjustment sleeve 220 with respect to the die body 200. Turbulence chamber 268 is where a first flash drying and decohesion of the processed synthetic elastomer takes place. As the material being processed passes through the pressure control system created by the adjustable space between conical surface 204 of the die body 200 and conical surface 244 of the filter screen 240, a reduction in pressure occurs allowing the material being processed to break apart and form crumbs due to the rapid vaporization of a portion of the moisture trapped within the material.

[0027] A second flash drying of the material being processed occurs as the material passes from the turbulence chamber 268 through the plurality of flash channels 250. Upon passage of the still super heated material through flash channels 250 and sudden exposure to atmospheric pressure, substantially all of the remaining moisture in the material being processed instantly enters a vaporous state.

[0028] As previously mentioned, the energy necessary to produce the flash drying effect is transferred to the material being processed from a screw drive in the expander. This energy is made possible, in part, by the resistance of the material to exit the expander through the die. This resistance is controlled in large measure in the present subject matter by the controlled spacing between conical surfaces 204 and 244.

[0029] With further reference, in particular, to Figure 3, it will be noted that there is illustrated an arrow "A" indicating rotation of the adjustment sleeve 220 relative to the die body 200. Rotation of the adjustment sleeve 220 in the direction of arrow "A" produces movement of the adjustment sleeve and, consequently, movement of the attached filter screen 240, in the direction of arrow "B." That is rotation in the direction of the arrow "A" "opens" the space between the conical surfaces 204, 244. Conversely, of course, rotation in a direction opposite to arrow "A" "closes" the space between the conical surfaces 204, 244. In an exemplary configuration, the threads 206 of the die body and threads 226 of the adjusting sleeve may be configured such that a total of five (5) complete revolutions of adjustment sleeve 220 will move the filter screen 240 from a substantially closed, i.e. zero setting, position to an effectively fully open, i.e. 100%, position. During normal operation of the variable die of the present subject matter, given the "zero" and "100% open" definitions just mentioned, a normal operation range might comprise between 5% open and 95% open.

[0030] Rotation of the adjustment sleeve 220 may be effectively implemented by way of ring gear 260, most clearly seen in the exploded view of die head 110 illustrated in Figure 5. Ring gear 260 is configured to cooperate with additional gearing, not shown, internal to expander head 100 that acts in concert with shaft 130 to simultaneously adjust all of the die heads 110 associated with expander head 100. As previously noted, such adjustment of the die heads 110 may be controlled by way of automated means which, although not illustrated, will be well understood by those of ordinary skill in the art to which the present subject matter pertains.

[0031] An important aspect of this opening and closing of the space between conical surfaces 204 and 244 is that a new mechanism has been provided permitting real time adjustment of the pressure applied to and the temperature generated in the material being processed. Prior to the teachings of the present subject matter, such control was obtainable only by stopping the production line and manually modifying the die setup. Clearly such prior modification technique was detrimental to efficient operation of the extruder-expander system. A yet more significant improvement in the operation of extruder-expander systems is possible as those of ordinary skill in the art grow to appreciate that the adjustment of the space between conical surfaces 204, 244 and thus the pressure and temperature of the process material, can be controlled automatically through microcontroller, computer, microprocessor or other automated processing devices.

[0032] Referring briefly to Figure 4, there is illustrated an operational embodiment of the present invention. As shown, material 300 to be processed and containing significant amounts of moisture, is forced through die head 110 in the direction of arrow "C" by a transport mechanism, not shown, but which may include a screw conveyor device. The amount of energy necessary to force the material 300 through the die head 110 is determined, in part, by the pressure adjusting spacing between conical surfaces 204, 244. As the material enters the pressure adjusting space and flows into turbulence chamber 268, a portion of the contained moisture is released from the material 300 due to the pressure drop as the material 300 enters the turbulence chamber 268. The pressure drop within turbulence chamber 268 and the subsequent release of moisture produces decohesion of the material 300 creating a crumbled form of the material 300. Finally, as the now crumbled material passes through flash channels 250, additional moisture is removed from the crumbled material as the

pressure on the material is suddenly reduced to atmospheric pressure and substantially all of the remaining moisture turns to vapor.

[0033] While the present subject matter has been described in detail with respect to specific embodiments thereof, it will be appreciated that those skilled in the art, upon attaining an understanding of the foregoing may readily produce alterations to, variations of, and equivalents to such embodiments. For example, while the present invention has been described in use with drying mixtures containing elastomeric particles, the present invention is not so limited. Accordingly, the scope of the present disclosure is by way of example rather than by way of limitation, and the subject disclosure does not preclude inclusion of such modifications, variations and/or additions to the present subject matter as would be readily apparent to one of ordinary skill in the art using the teachings disclosed herein.

WHAT IS CLAIMED IS:

1. A variable die assembly, comprising:

a die body having an inner portion and an outer portion;

an adjustment sleeve having an inner portion and an outer portion; and

a filter screen, secured in said adjustment sleeve and movable with respect to said die body, so as to allow dynamic control of the pressure applied to material passing through the die.

2. A variable die assembly as in claim 1, wherein at least a portion of the outer portion of the die body and a portion of the inner portion of the adjustment sleeve are cylindrical and correspondingly threaded.

3. A variable die assembly as in claim 1, wherein said filter screen has an outer surface and an inner surface and is secured in said adjustment sleeve with the inner surface directed toward an end portion of said die body and wherein the inner surface of the filter screen and an end portion of the die body have mating surfaces.

4. A variable die assembly as in claim 3, wherein the mating surfaces are frustoconical.

5. A variable die assembly as in claim 1, further comprising:

a gear mounted on a portion of the outer surface of said adjustment sleeve, whereby movement of said adjustment sleeve relative to said die body may be effected to dynamically control pressure applied to material passing through the filter screen.

6. A variable die assembly as in claim 5, wherein said gear is a ring gear.

7. A variable die assembly as in claim 1, wherein said filter screen further comprises:

a predetermined number of through holes passing from the outer surface of the filter screen toward the inner surface; and

a channel circumscribing the inner surface and connecting the through holes in common.

8. A variable die assembly as in claim 1, wherein said filter screen is threaded into an end portion of said adjustment sleeve.

9. A method for flash drying material, comprising the steps of:

providing a dynamically adjustable die assembly, the assembly comprising a die body, an adjustment sleeve and a filter screen; and

forcing material to be dried through the die assembly.

10. The method of claim 9, wherein the step of providing comprises:

providing a filter screen with a plurality of flash channels and a turbulence channel coupling each of the plurality of flash channels.

11. The method of claim 9, wherein the step of providing further comprises:

providing a variably adjustable obstruction between the filter screen and a portion of the die body.

12. The method of claim 11, where the step of providing a variably adjustable obstruction comprises:

providing a protrusion on the inner surface of the filter screen; and

providing a mating surface on a portion of the die body.

13. The method of claim 12, wherein the step of providing a protrusion comprises providing a frustoconical protrusion.

14. A method of optimizing flash drying of material, comprising the steps of:

providing a dynamically adjustable die assembly, said die assembly comprising a filter screen, a die body and a dynamically variable pressure adjuster between said die and said die body;

forcing material through the die body, the dynamically variable pressure adjuster and the filter screen at controllable flow rates; and

varying the controllable flow rates and the pressure adjuster,

whereby adjustment of the controllable flow rates and pressure adjuster provide optimizing control of the pressure and temperature applied to and generated in the material.

15. The method of claim 14, wherein the step of providing a dynamically adjustable die assembly further comprises the step of:

providing a portion of the filter screen and a portion of the die body with mating surfaces.

16. The method of claim 14, wherein the step of providing a dynamically adjustable die assembly further comprises the step of:

providing a portion of the filter screen and a portion of the die body with mating frustroconical surfaces.

17. The method of claim 14, further comprising the steps of:

providing the filter screen with a plurality of flash channels; and

providing a turbulence channel connecting the plurality of flash channels,

whereby, as material flows through the die body, the pressure adjuster, the turbulence channel and the flash channels, seriatim, a first flash drying of the material is produced in the turbulence channel and a second flash drying of the material is produced at the flash channels.

18. The method of claim 14, wherein the step of providing a dynamically adjustable die assembly further comprises the step of:

providing the die body and the adjustment sleeve with matching threaded portions.

20. An adjustable die assembly for use in removing liquid from a mixture, comprising:

a die body defining a first surface located along a first end of the die body;

a die positioned proximate to the first end of the die body, the die having an interior side that defines a second surface, wherein the first surface and the second surface define a passage for the flow of the mixture during operation of the die assembly;

an adjusting element in mechanical communication with the die and the die body, the adjusting element providing for the relative movement of the die relative to the die body so as to allow adjustment of the size of the passage during operation of the die assembly.

21. An adjustable die assembly as in claim 20, wherein the first and the second surfaces are frustoconical in shape.

22. An adjustable die assembly as in claim 21, wherein the die is removably attached to the adjusting element.

23. An adjustable die assembly as in claim 22, wherein the die body is removably attached to the adjusting element.

24. An adjustable die assembly as in claim 23, wherein the die defines a plurality of holes that are in fluid communication with a chamber configured for flashing the mixture during operation of the die assembly.

ABSTRACT OF THE DISCLOSURE

Apparatus and methodologies are provided for flash drying liquid materials using a variable die. A die and a die body are provided with an adjustably configured pressure regulating variable obstruction in the material flow path that allows control of the pressure applied to the material and consequent control of the temperature of the material as it enters the die. Optimizing pressure and temperature allows optimization of the flash drying process.

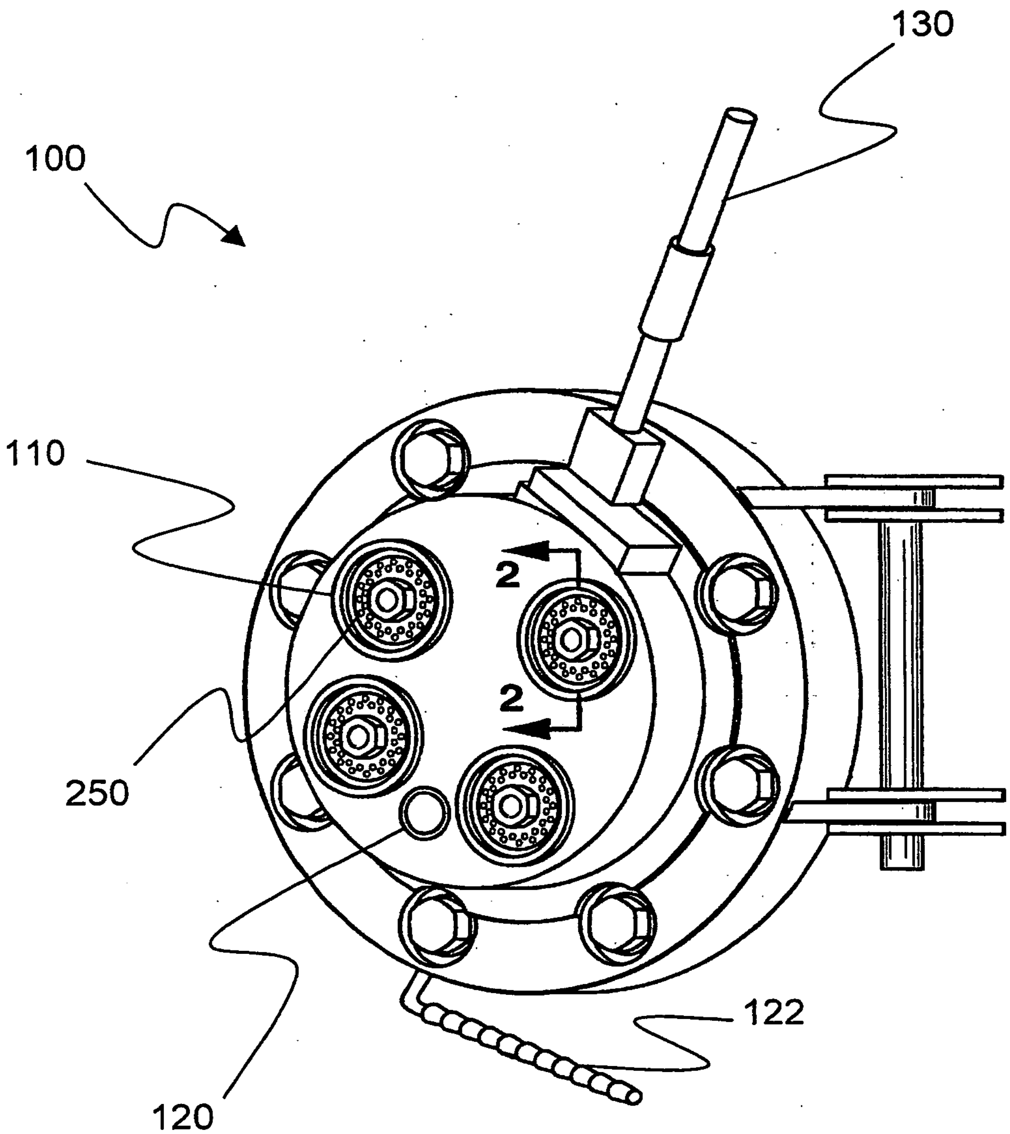
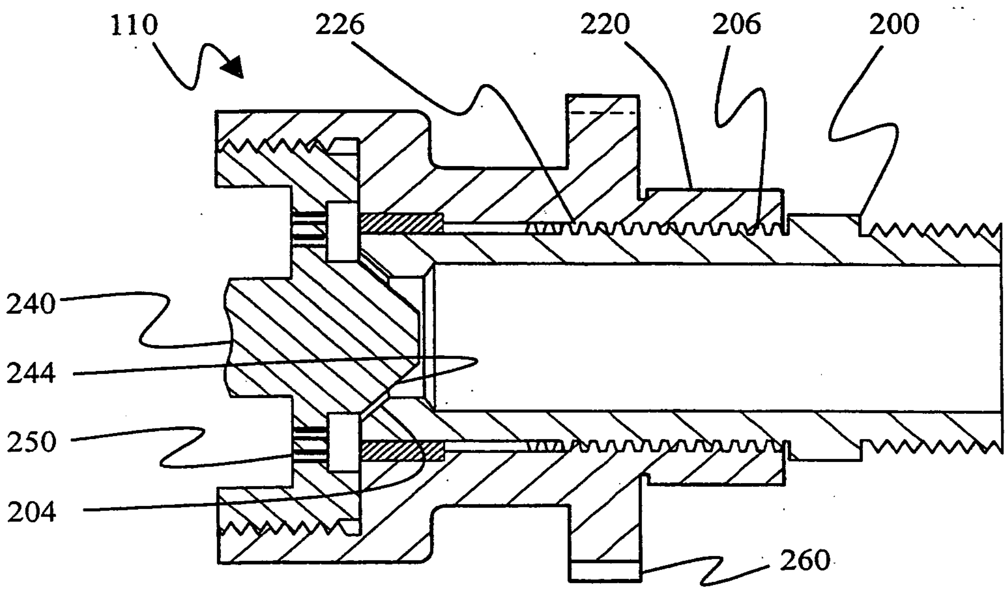


FIG. 1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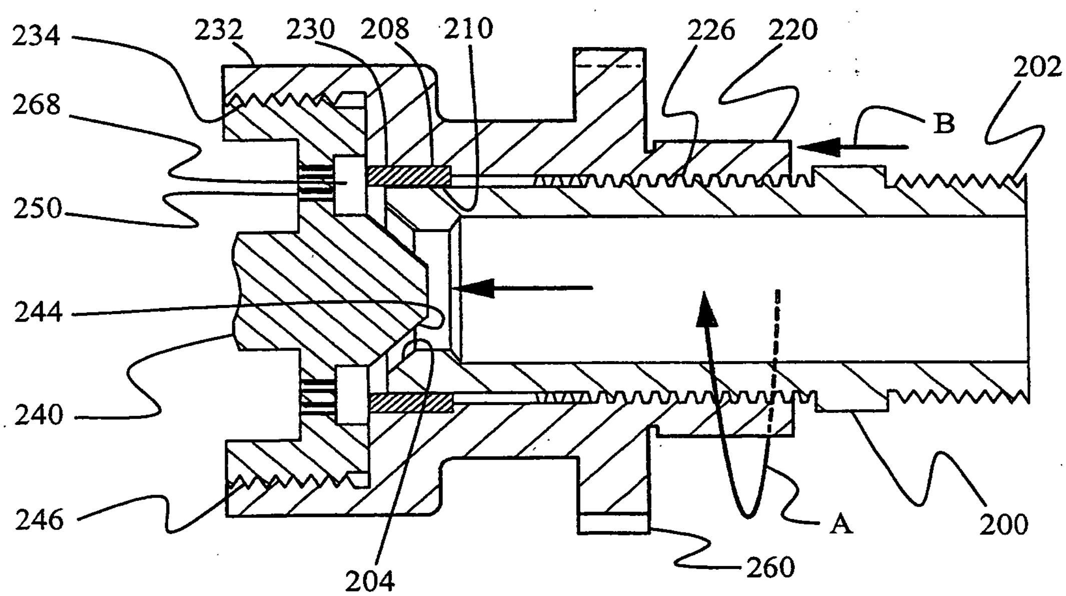
226
220
206
200
240
244
250
204
260

FIG. 2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232
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208
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226
220
202
268
B
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240
246
A
200
204
260

FIG. 3

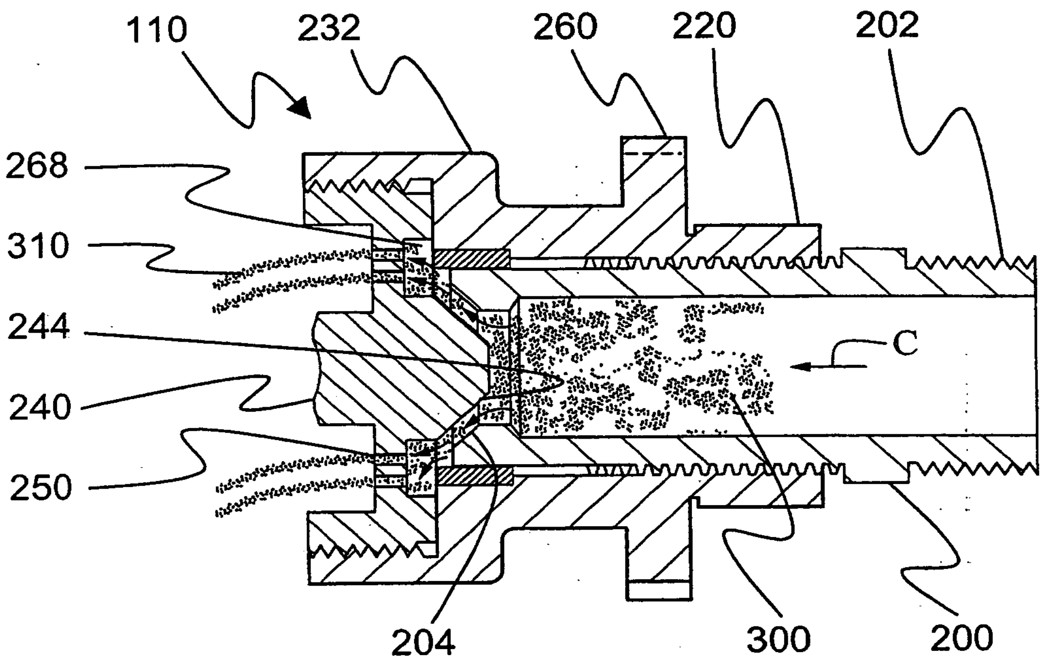

FIG. 4

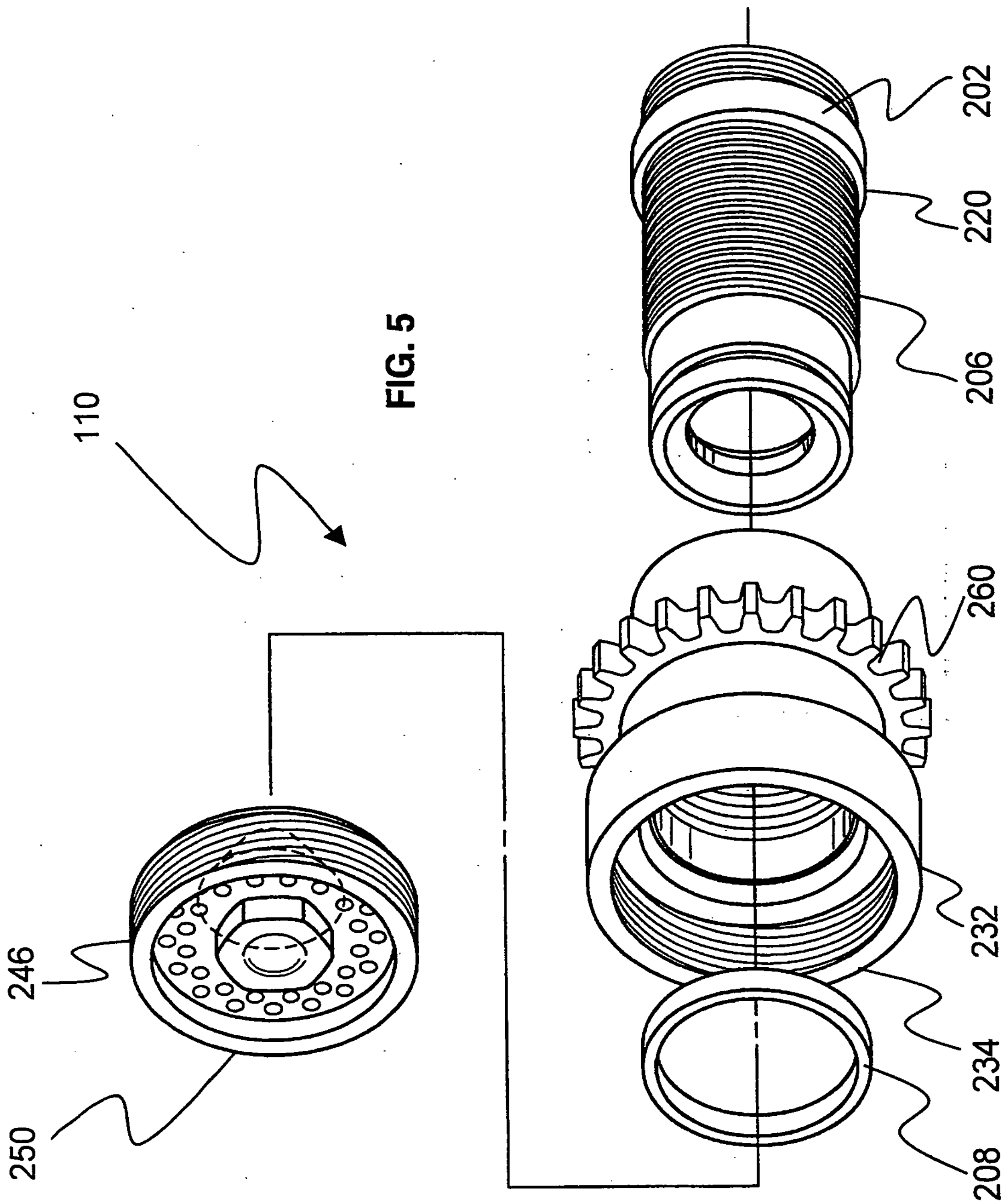

FIG. 5